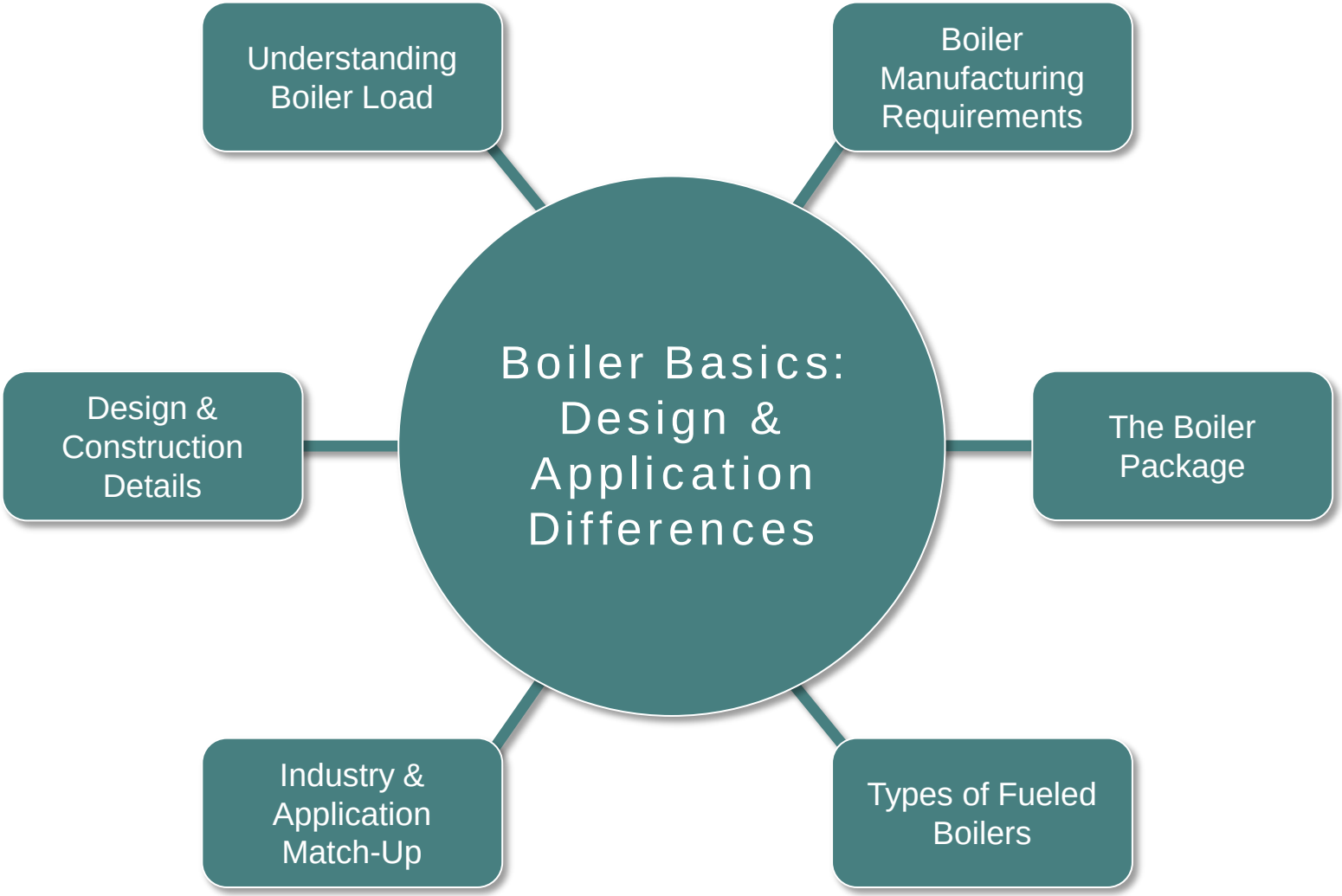
Boiler Basics:
Design & Application Differences

Presented by Steve Connor

July 30, 2014

What We Are Covering Today



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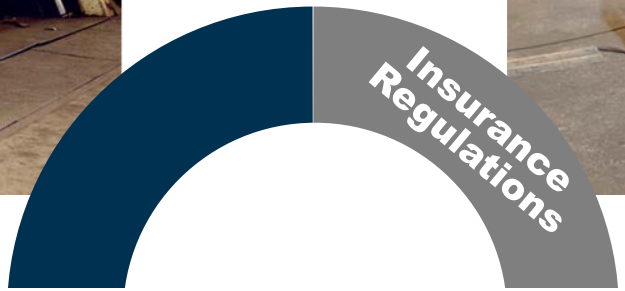
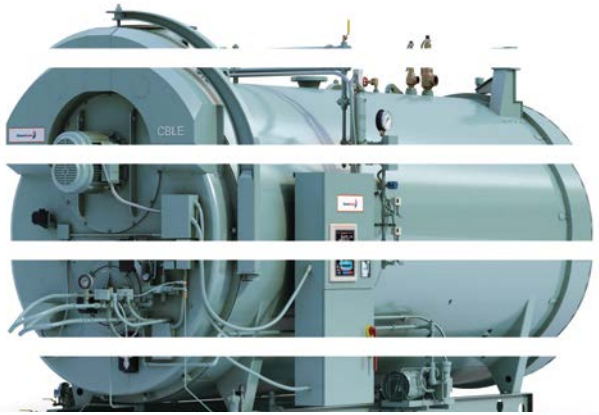
Boiler Manufacturing





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ASME Code

(American Society of Mechanical Engineering)

Section I

- High pressure - Steam boilers above 15 psi. Hot water boilers above 160 psi (hydrostatic pressure) and/or 250^0 F outlet temperature

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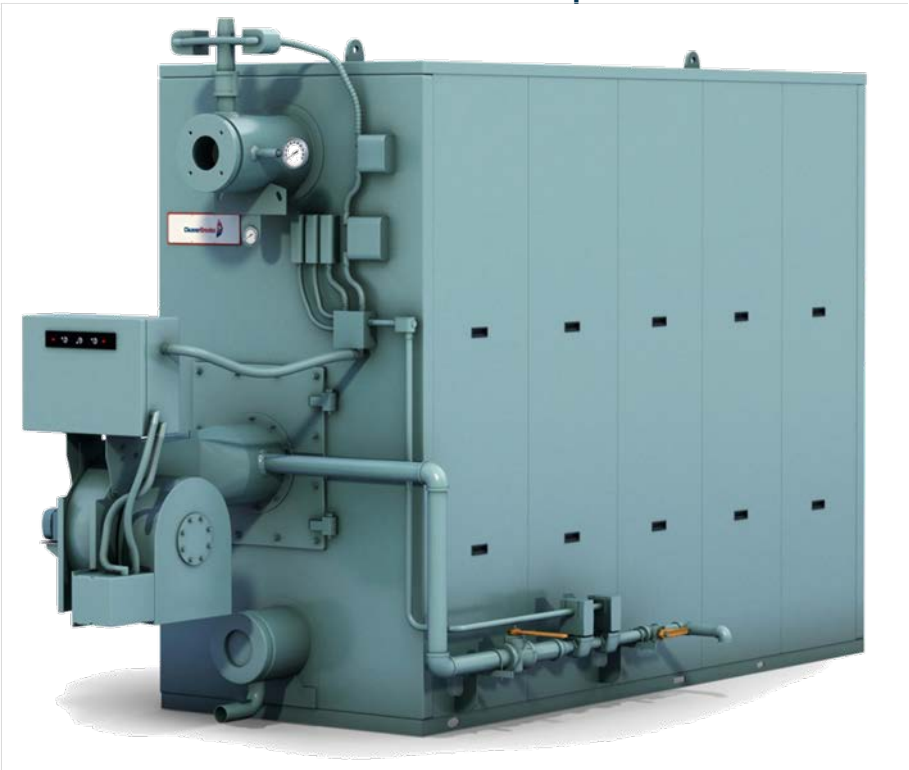
ASME Code

(American Society of Mechanical Engineering)

Section IV

- Low pressure - Steam boilers less than 15 psi. Hot water boilers less than 160 psi and/or 250^0 F. outlet temperature



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Packaged Boiler Types

General Categories

Electric

Tubeless

Firetube

Watertube

Capacity

200 – 365,000 MBH

6 – 11,000 BHP

Steam & Hot Water

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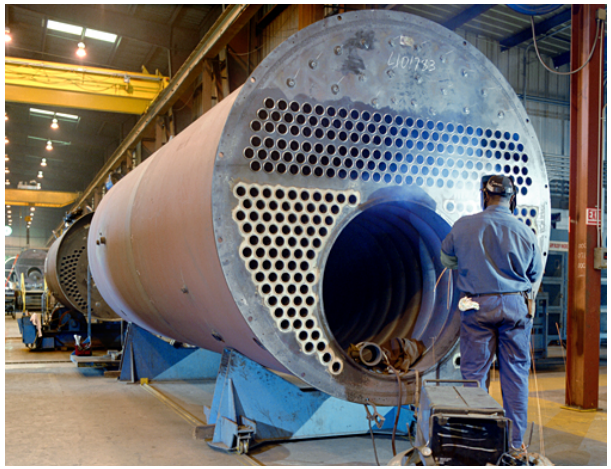
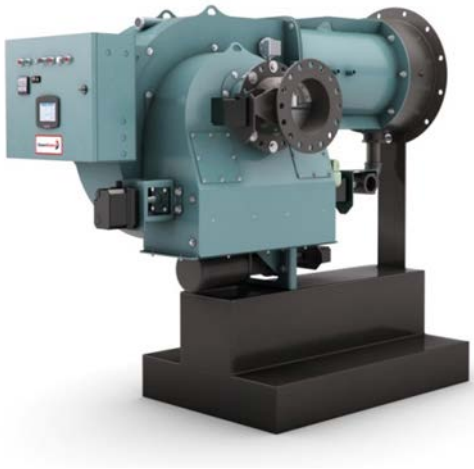
The Boiler Package

- Pressure vessel
- Burner
- Controls

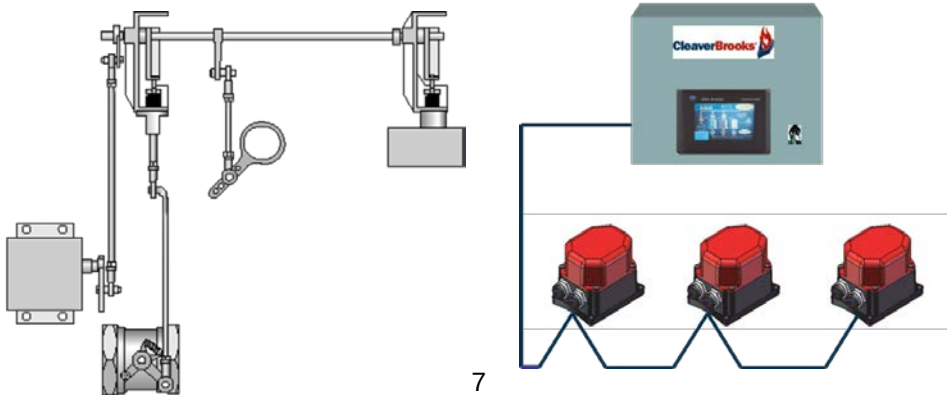
Pressure Vessel



Burner



Combustion Controls



Burner Management

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Broad Industry Breakdown

Commercial

Primarily Low Pressure or Hot Water Comforting Heating

Industrial

Primarily Process Applications with some Comfort Heating

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Commercial Steam & Hot Water

- Firetube
- Vertical Tubeless
- Electric
- Watertube
- Cast Iron
- Copper Fin

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Industrial Steam & Hot Water

- Firetube
  - Horizontal
  - Vertical
- Vertical tubeless
- Electric
- Watertube
  - Natural
  - Forced Circulation
- IWT

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Packaged Firetube Details

Horizontal Firetube

- Size range: 15 – 2200 HP
- Design pressures:
  - Steam: 15 - 250#
  - Water: 30 – 160#

Vertical Firetube

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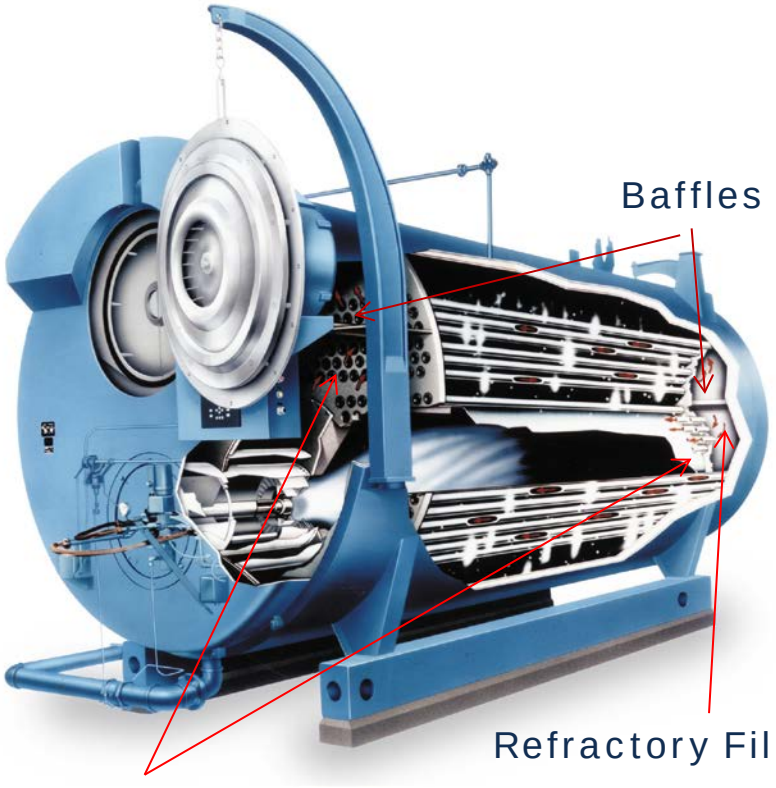
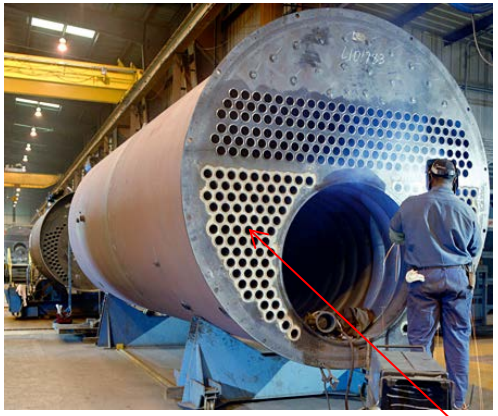
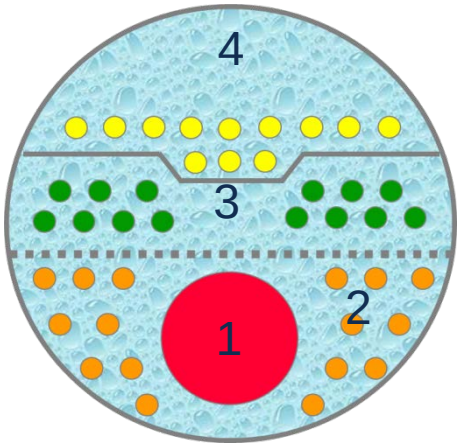
Horizontal Firetube Boilers

The Dryback







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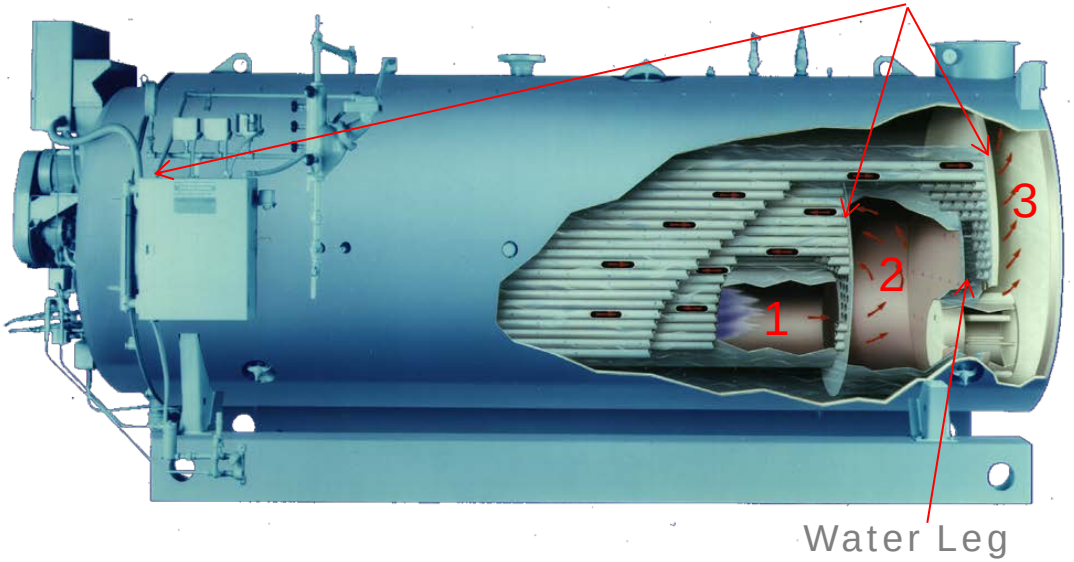
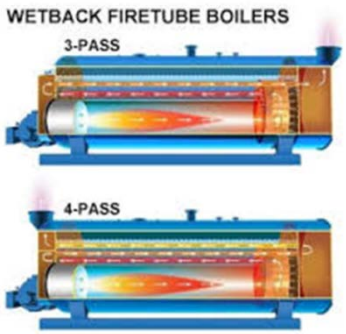
Horizontal Firetube Boiler

The Wetback



- Three Tubesheets
- Difficult access, 2nd pass



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Vertical Firetube Boiler

- Size range: 10 – 60 HP
- Design Pressures:
  - Steam: 150#
  - Water: 125#
- Compact

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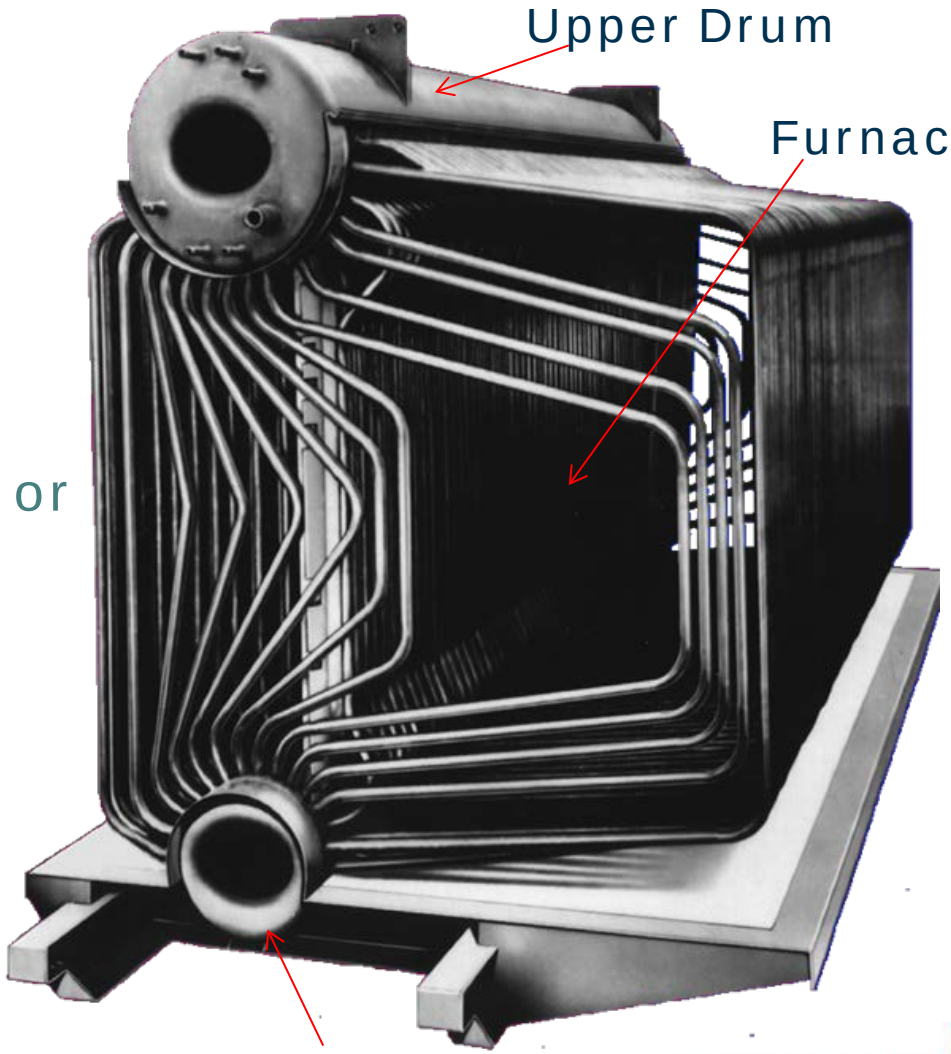
The Watertube Boiler

- Opposite of Firetube
- Water in the Tubes
- Natural and Forced Circulation
- Large Furnace
- Upper & Lower Drums or Headers



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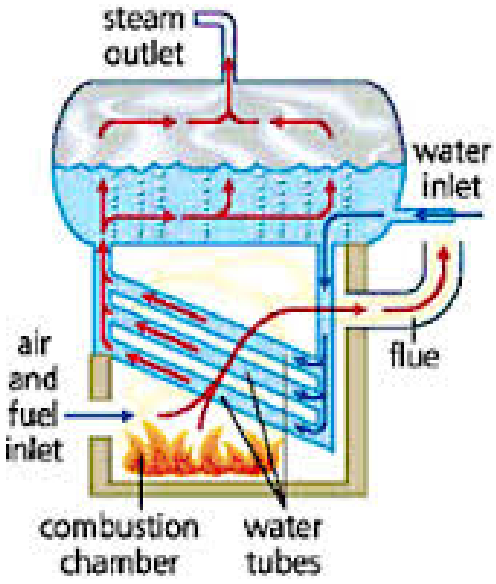
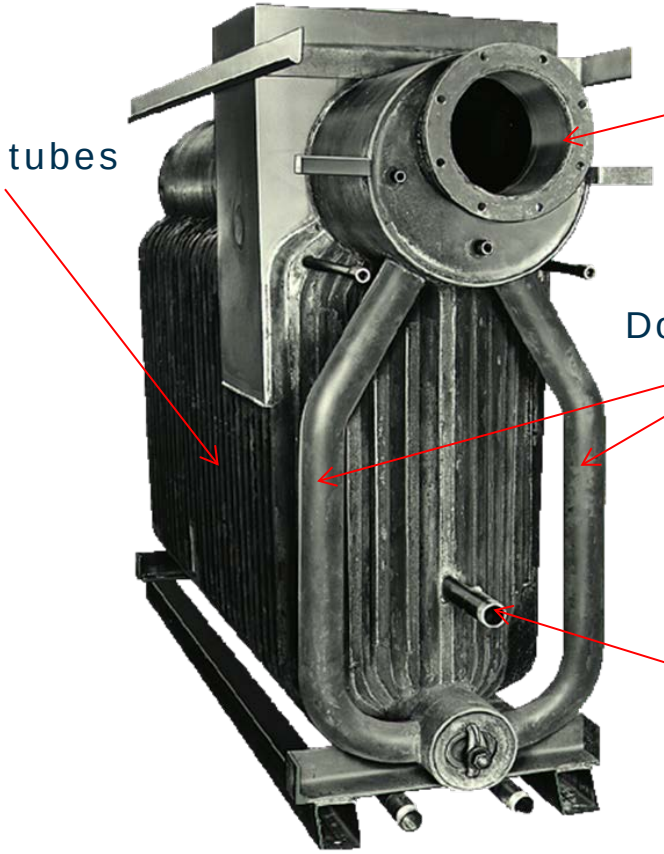
The Watertube Boiler

- Size Range: 15 – 300 HP
- Design Pressure:
  - Steam: 250#
  - Hot Water: 125#

Straight Inclined



Bent



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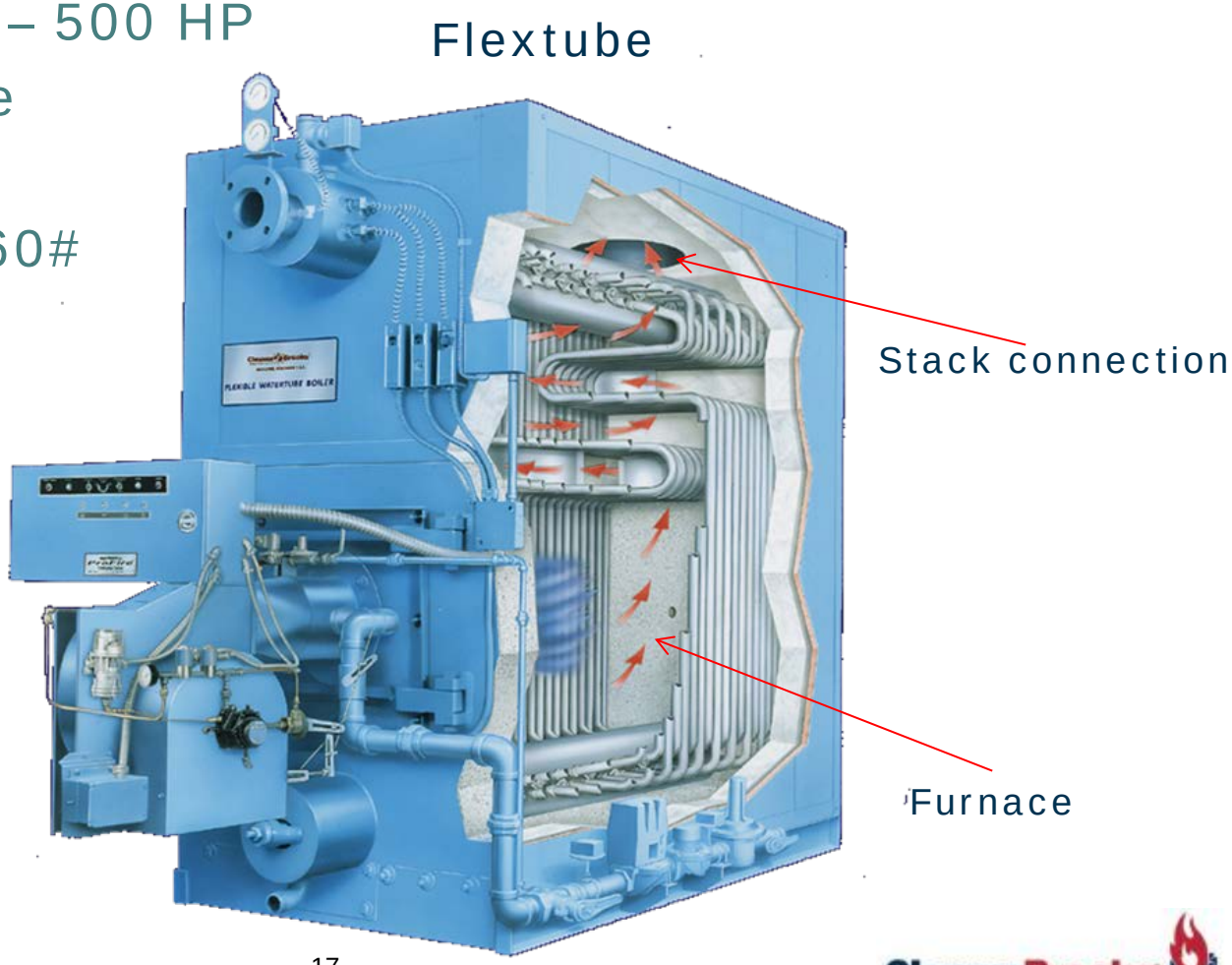
The Watertube Boiler

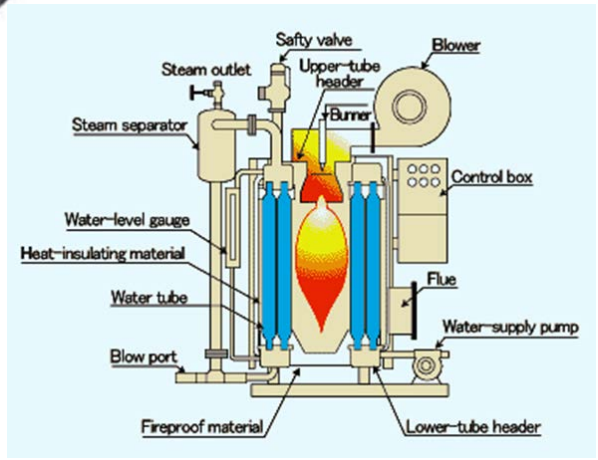
- Size Range: 35 – 500 HP
- Design Pressure
  - Steam: 150#
  - Hot Water: 160#



The Watertube Boiler

- Size Range: 100 – 300 HP
- Design Pressures:
  - Steam: 170#
- Requires Forced Circulation
- Low Water Volume
- Fast Steamer
- Water Quality is Critical

Forced Circulation Generator



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The Watertube boiler

- Size Range: 6 – 300 HP
- Design Pressures
  - Steam: 15#
  - Hot water: 60 - 80#

Cast Iron

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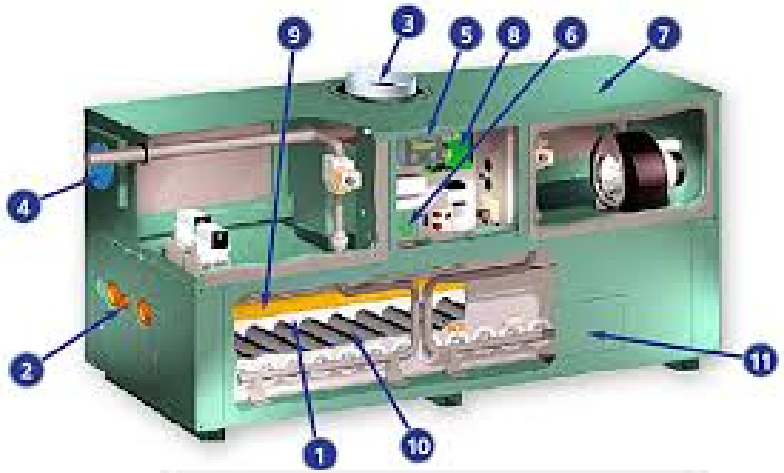
The Watertube boiler

- Size Range: 15 – 70 HP
- Design Pressure:
  - Hot Water: 160#
- No Steam
- Requires Circulation
- Atmospheric Burner or with Fan Assist

Copper fin



Tube bundle

Header

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The Watertube boiler package

- Size Range: 10,000 – 300,000#/HR
- 300 – 9000 HP
- Design Pressure:
- Steam: to 900#
- HTHW: +400 Deg. F
- Natural Circulation
- Some Forced Circulation

IWT

“D”

“O”

“A”

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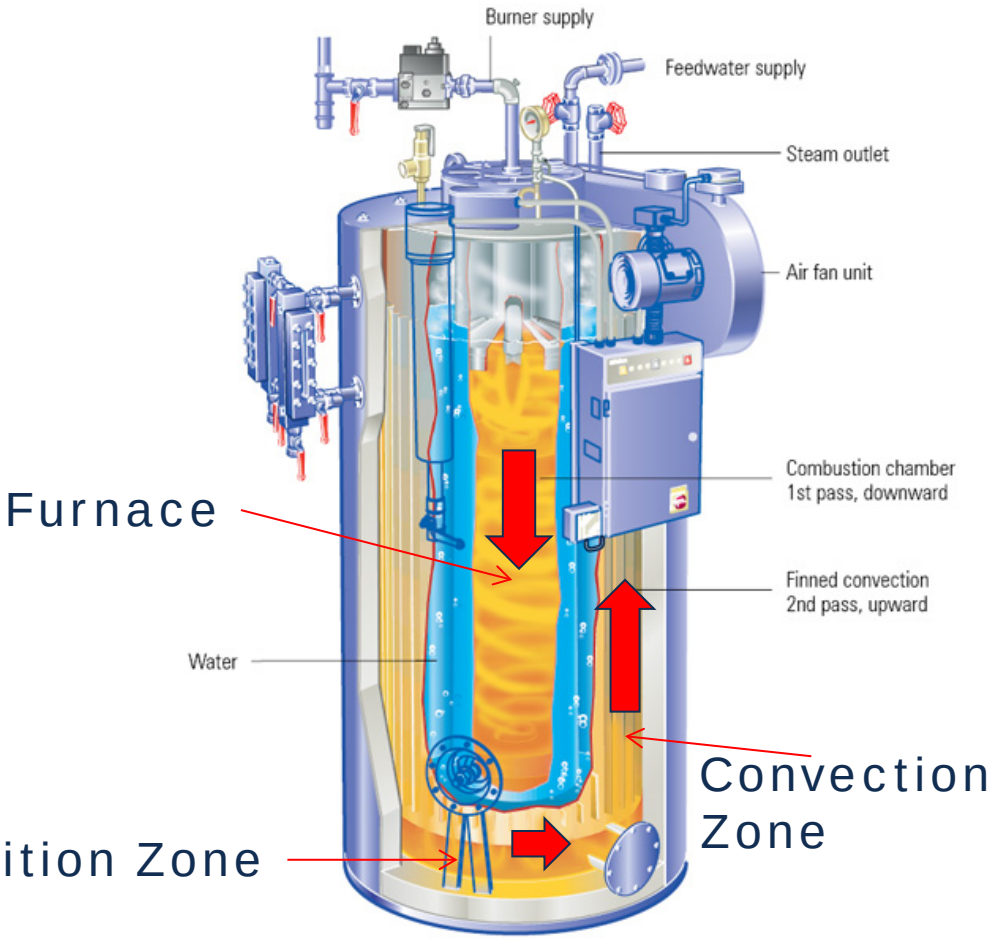
Vertical Tubeless boiler

- Size Range: 6 – 100 HP
- Design Pressure:
  - Steam: 150 - 250#
  - Hot Water: 160#
- Multiple Passes (2 – 4)

2 Pass Design



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Electric Boilers

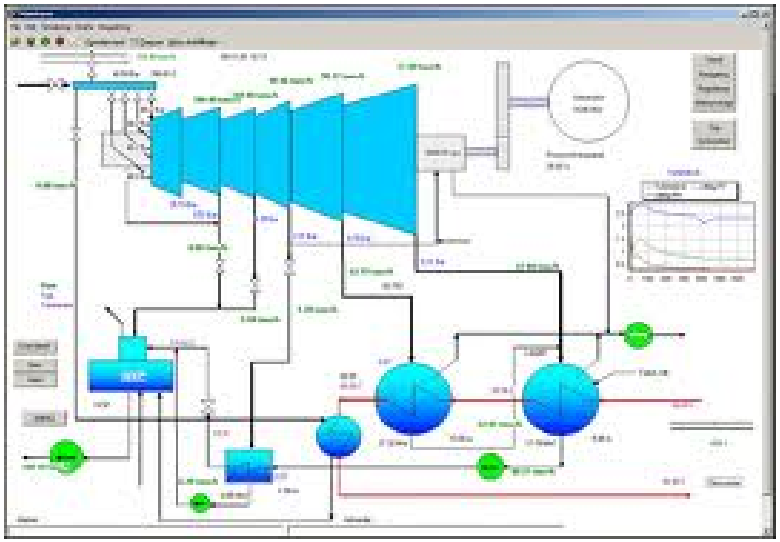
- Size range:
  - Resistance: 12 – 3375 KW (1 – 350 BHP)
  - Electrode: 2 – 65 MW (200 – 7000 BHP)
- Design Pressure
  - Steam: To 250#
  - Hot water (Resistance) 160#
- No Emissions on Location
- High Point of Use Efficiency

Electrode

Resistance

NOTE:
MW = 1,000,000 watts
KW = 1000 watts or 3413 BTU/HR

Understanding the Load



Initial Questions:

- Total load?
- Pressure?
- Cyclicality?
- Load majority?
- Steam quality requirement?

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Boiler Choice

Firetube?

Watertube?

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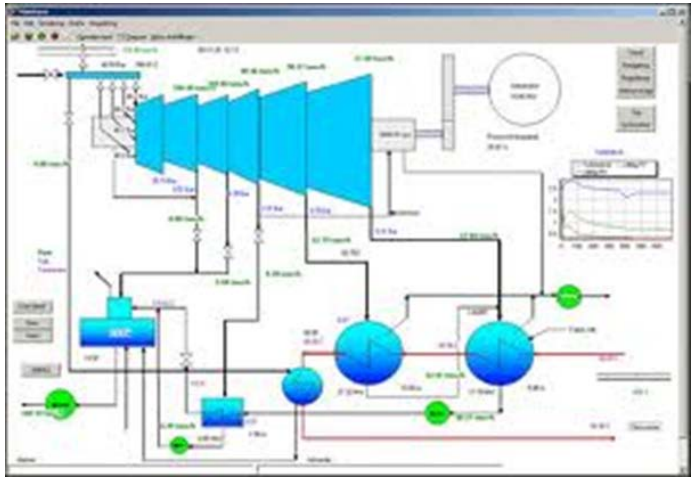
Cyclicality



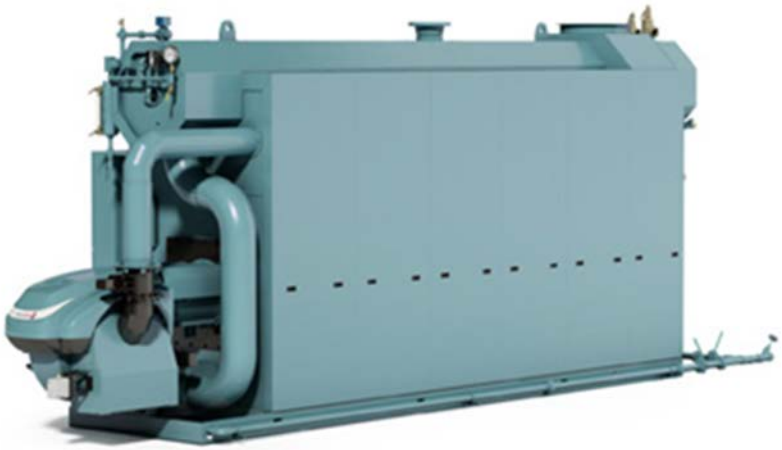
- Spikes in demand?
- How much add to my normal load?
- How fast do they occur?
- Sudden or gradual?
- Maintaining pressure critical?

Cyclicality

Bent Tube

IWT

Flextube



Sudden swings in load??

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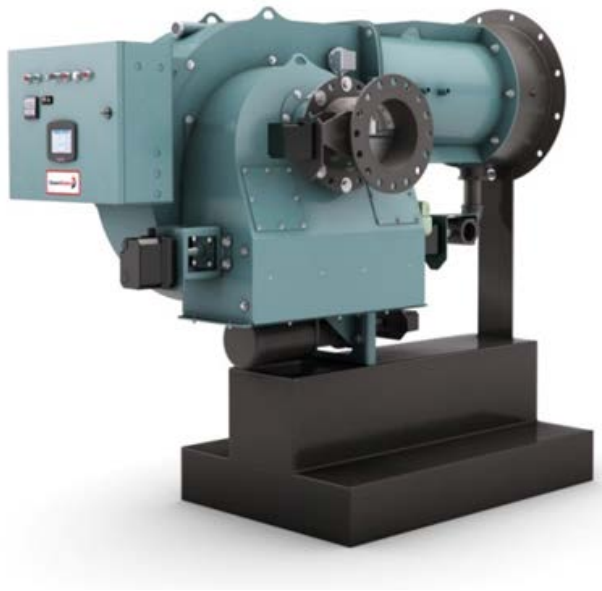
Burner Choice

Sized for optimum firing rate majority of operating time.

Normally 4:1 or 10:1



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Purge Losses

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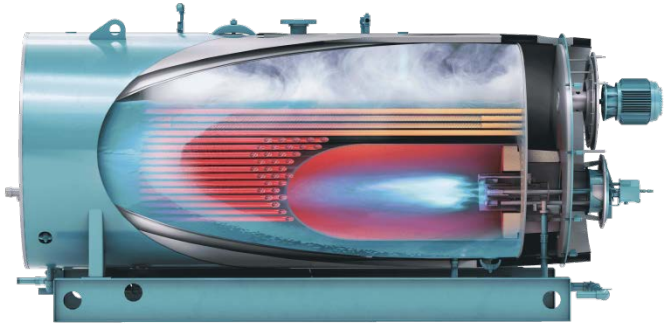
Load Majority



Boiler's "Sweet spot"

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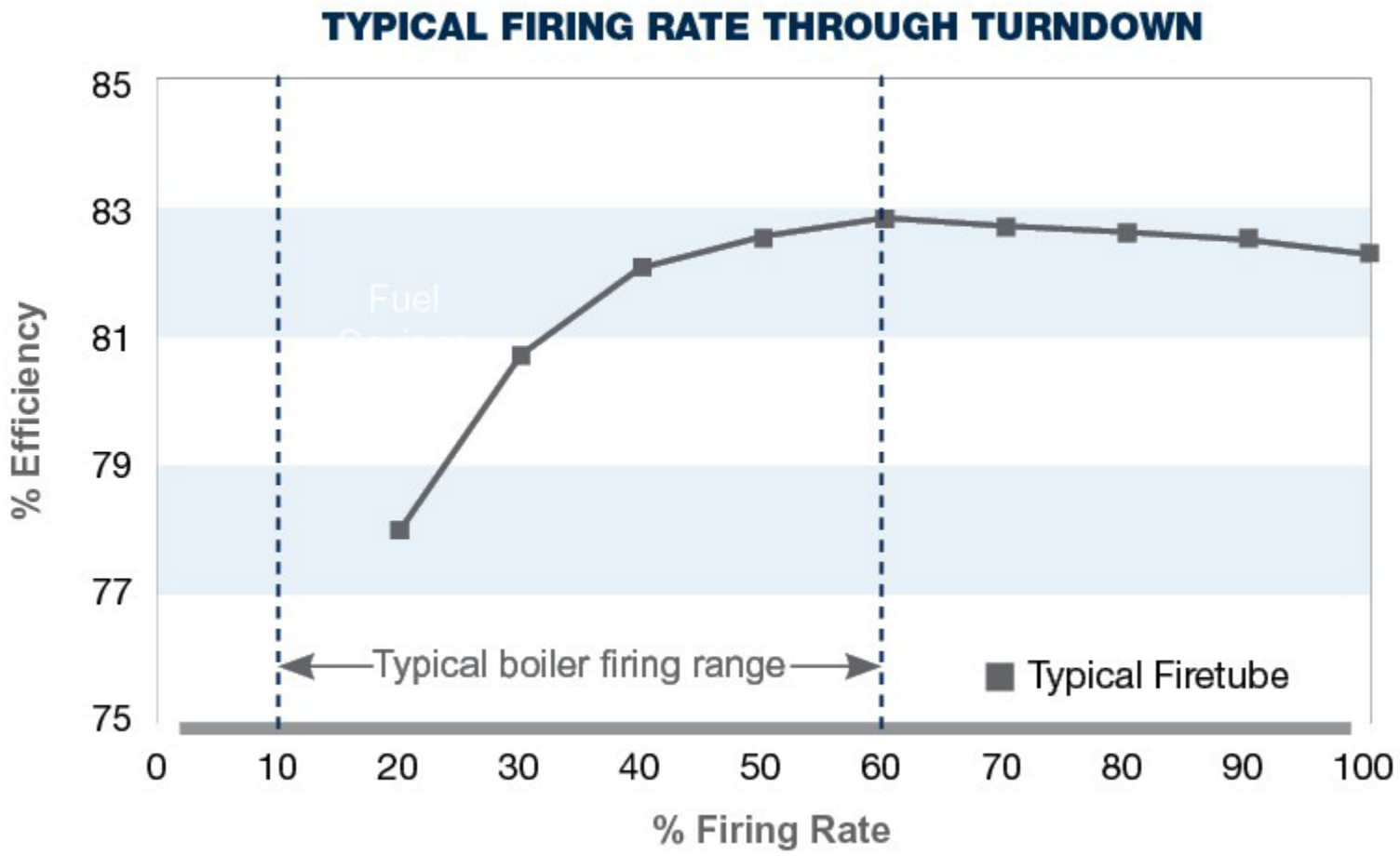
Boiler Efficiency & Firing Rate



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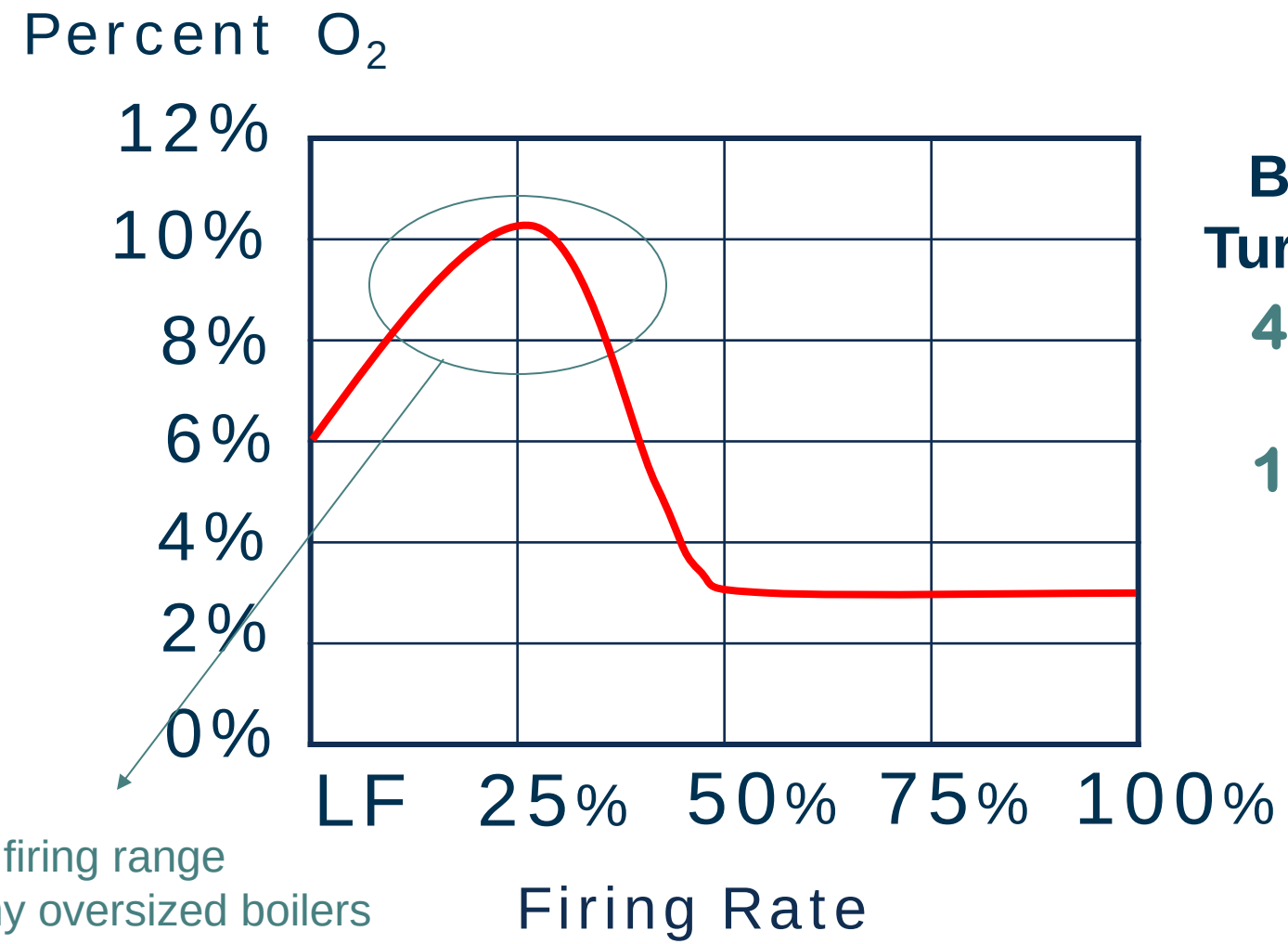
Burner Choice



Burner Turndown

4 To 1 or 10 to 1

Typical firing range for many oversized boilers

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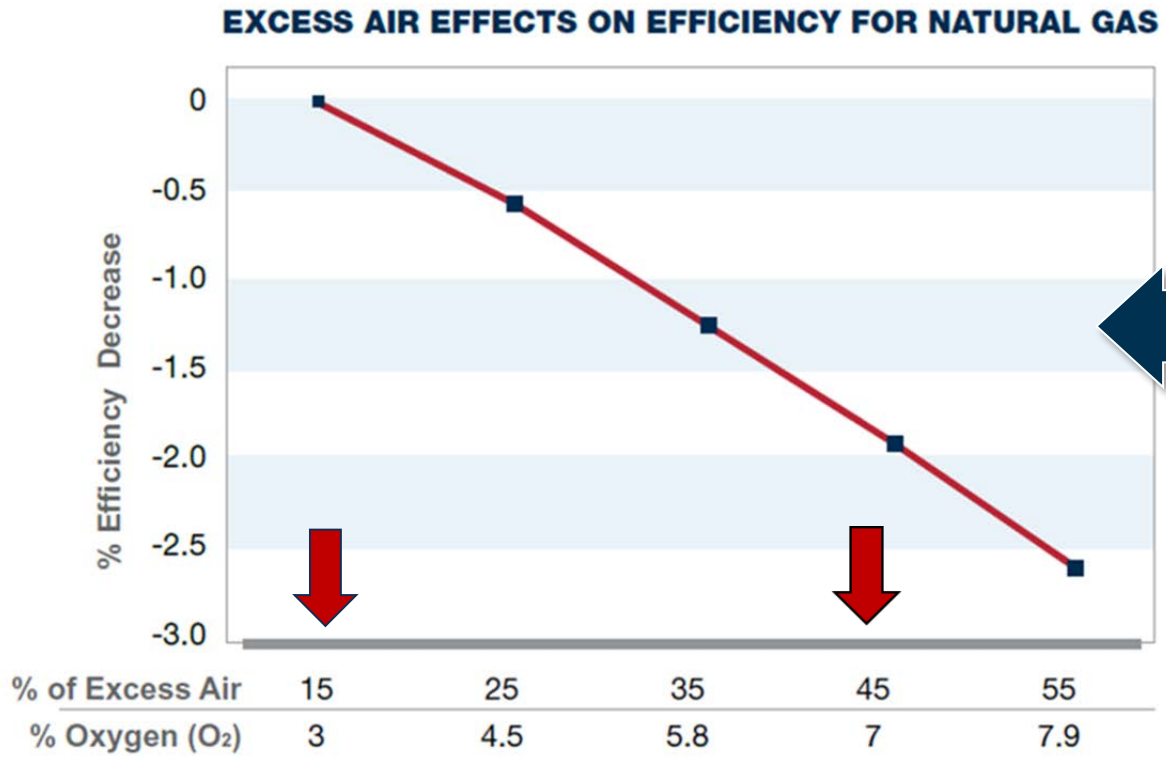
Burner Choice



RULE OF THUMB

For every 2% increase in O_2, you lose 1% in efficiency

PDF

Reference PDF Available:
http://cleaverbrooks.com/Products-and-Solutions/Boilers/Firetube/CBEX-Elite/Excess-Air-and-Boiler-Efficiency.aspx

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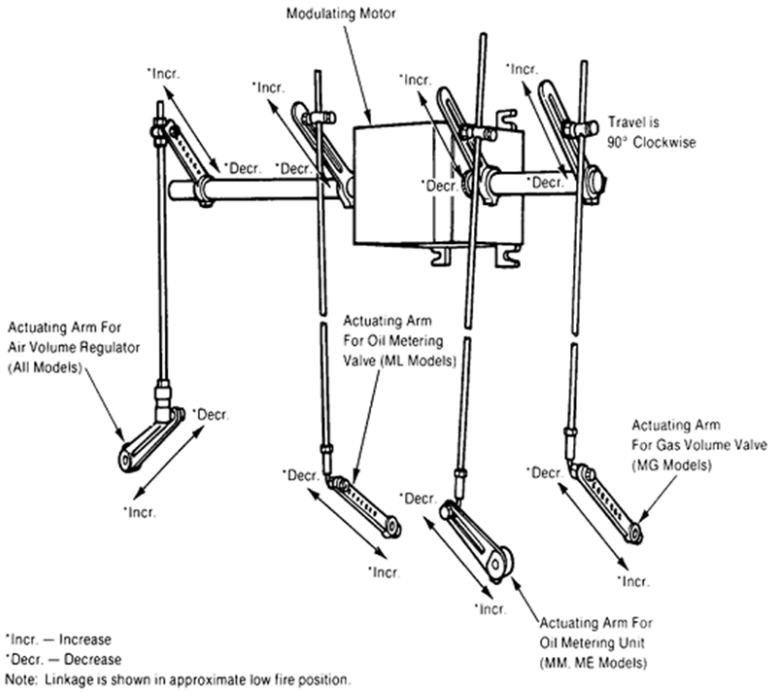
Combustion Control Choice

Single Point



Parallel Positioning

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Multiple Boilers

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Central Control Unit

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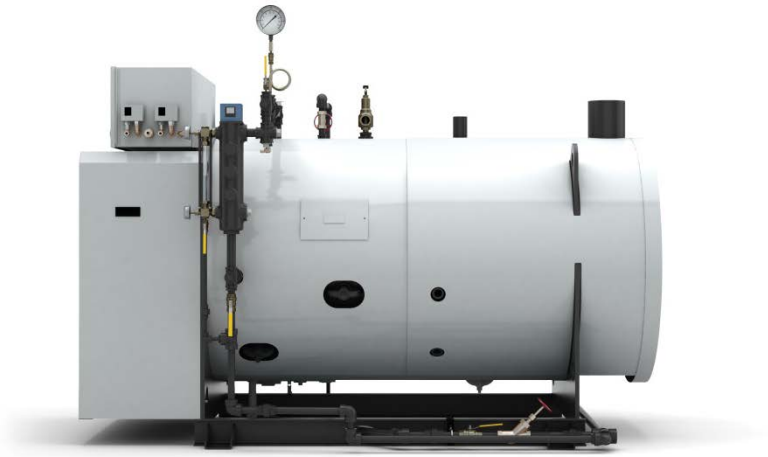
Summer boiler

Smaller Summer Boiler



Complete Skidded Package

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Steam Quality

AMERICAN BOILER MANUFACTURER'S ASSOCIATION
ABMA

WATERTUBE BOILERS
RECOMMENDED BOILER WATER LIMITS
AND ASSOCIATED STEAM PURITY
DRUM-TYPE BOILERS
(At Steady State, Full-Load Operation)

Drum Pressure PSIG	Range Total Dissolved Solids (1) Boiler Water ppm (MAX)	Range Total Alkalinity Boiler Water ppm (2,5)	Susp'd Solids Boiler Water ppm (MAX)	Range Total Dissolved Solids (2,4) Steam ppm
0-300	700-3500	140-700	15	0.2-1.0
301-450	600-3000	120-600	10	0.2-1.0
451-600	500-2500	100-500	8	0.2-1.0
601-750	200-1000	40-200	3	0.1-0.5
751-900	150-750	30-150	2	0.1-0.5
901-1000	125-625	25-125	1	0.1-0.5
1001-1800	100	NOTE (3)	1	0.1
1801-2350	50	NOTE (3)	N/A	0.1
2351-2600	25	NOTE (3)	N/A	0.05
2601-2900	15	NOTE (3)	N/A	0.05

TDS Control

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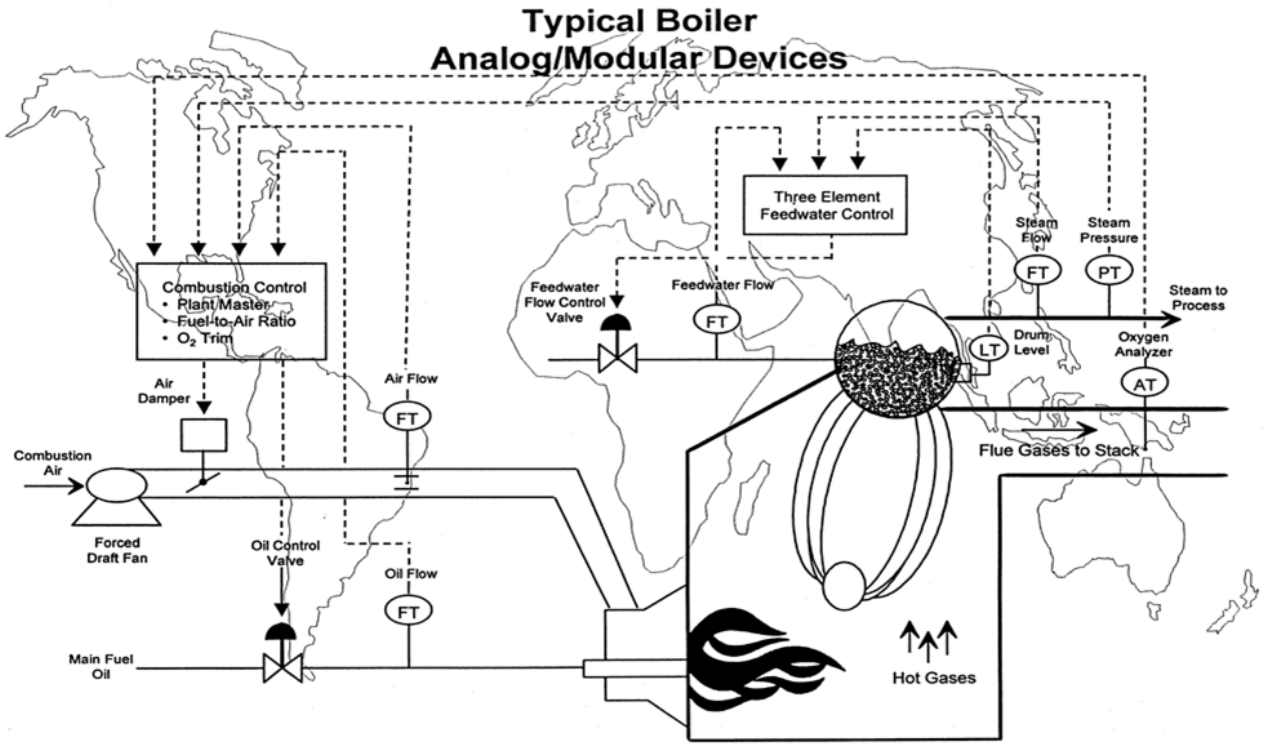
Steam Quality



Three Element Control System

Monitoring water level, steam flow and feedwater flow

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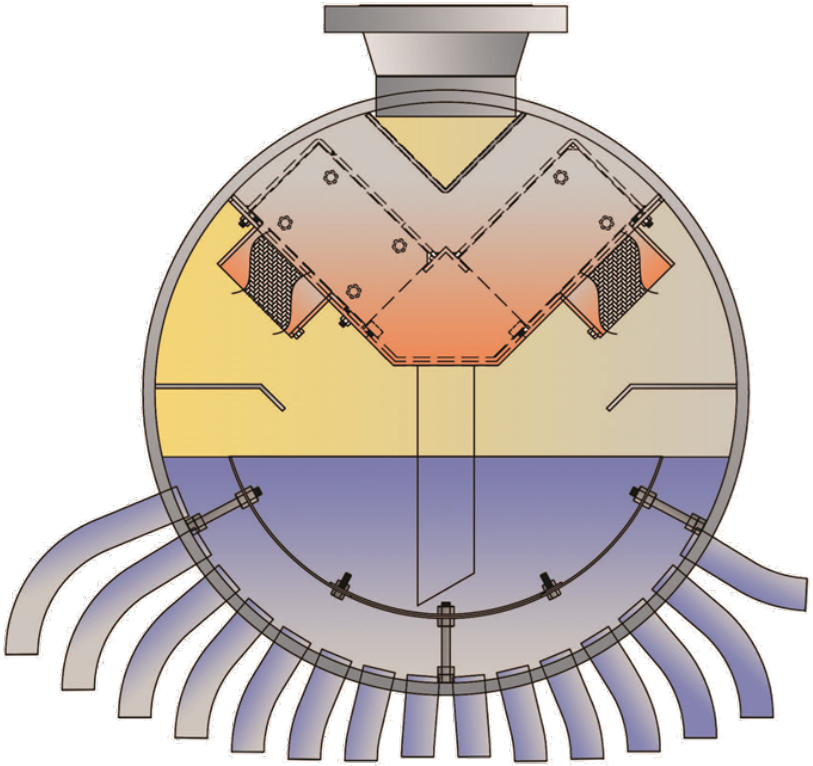
Steam Quality



- Secondary separation with labyrinth or chevron internal separators
- Steam endures a tortuous path
- End result is 99.5% dry steam, or < 0.5% moisture to process

Steam Quality

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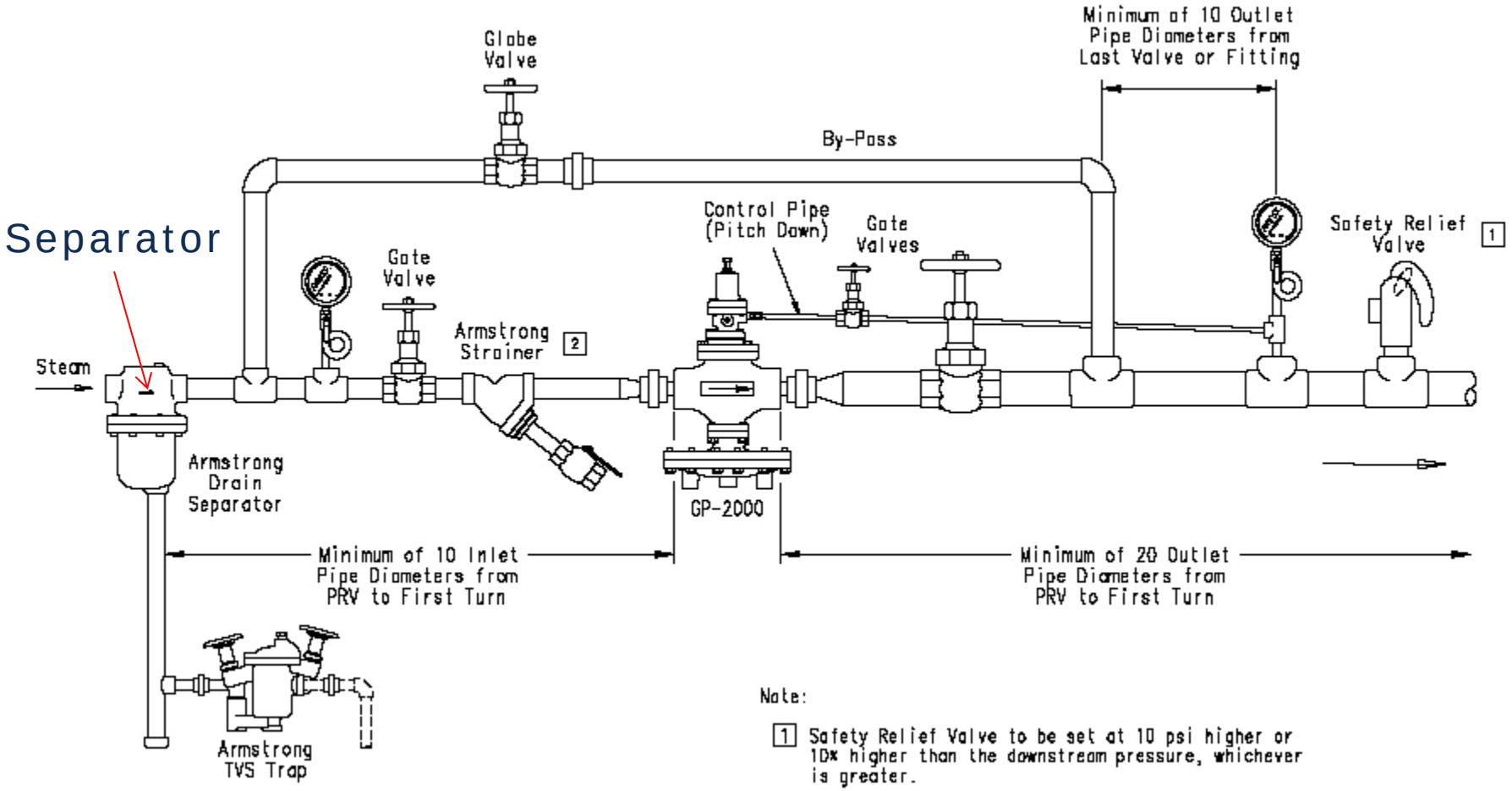
Steam Quality



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Summary

- Boilers constructed per ASME Sections I (HP) & IV (LP & HW)
- The boiler package consists of pressure vessel, burner & controls (BMS & CCS)
- Various types of firetubes & watertubes
- Firetube package limit @ 2200 HP and 250#
- Watertube packages limit at 9000 HP & 900#
- The watertube boiler is normally superior in handling “swing” loads
- Cast Iron boilers are LP & HW only
- Copper boilers are HW only
- When considering the total load, look for cyclicality spikes
- Know where the load is the majority of the time assuring the spikes can be handled within the boilers turndown
- Know where the boiler’s “sweet spot” is
- Remember 2% increase in O2 = 1% loss in efficiency
- Steam quality can be a process issue

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